The diurnal variations in absolute humidity are chiefly dependent upon local conditions of evaporation from moist surfaces, and upon the balance between that source of supply of water vapor and any loss that takes place through condensation (dew, frost, etc.), all of these processes being largely under the control of temperature. Minima usually come at night, while maxima generally occur by day. All the interacting controls are subject to variations which depend upon permanent local conditions and upon temporary weather types.

CAUSE OF THE ACCELERATED SEA BREEZE OVER CORPUS CHRISTI, TEX.

By JOSEPH P. MCAULIFFE, Meteorologist.

[Weather Bureau, Corpus Christi, Tex., Sept. 12, 1922.]

SYNOPSIS.

The sea breeze at Corpus Christi attains unusually high velocities, becoming a fresh to strong southeast wind in the afternoon during summer. The same character of sea breeze is not to be found on either the northern or extreme southern Texas coast. The cause of this unusual sea breeze at this point is explained by reason of the topography of the hinterland of Corpus Christi and the contour of the coast line.

It has been established by observations extending over a period of 35 years and by comparison of average wind velocities on different parts of the Texas coast that the sea breeze attains unusually high velocities at Corpus Christi and its vicinity. This sea breeze comes from the southeast, usually begins after 8 a. m. and continues with increasing velocity during the day, frequently continuing as a moderate breeze throughout the night, but usually diminishing after midnight. It has an average velocity of 12 miles per hour at 10 a. m., when it usually becomes noticeable, and 19 miles per hour at 5 p. m., the time of its maximum force. By comparison with Galveston and Port Arthur it is readily seen that the sea breeze at Corpus Christi far surpasses the daily wind movement on the northern Texas coast. Comparison with places south of Corpus Christi has been impossible because of lack of data, but it is certain that no such wind velocities occur on the south Texas coast as those found near Corpus Christi.

While the average velocity of this breeze is remarkable, especially during the afternoon hours, the actual maxima attained are even more striking. Maximum velocities of 20 to 30 miles per hour, and sometimes higher, are frequent, due to nothing more than the natural flow of sea air landward. When accelerated by areas of low pressure in the interior, greater velocities are experienced. The regularity of this sea breeze is also remarkable; it is only during cloudy weather that it fails to be a fresh breeze.

The following tables show the average hourly velocities at Corpus Christi, Galveston, and Port Arthur during the three summer months of June, July, and August, and the average velocities at 10 a. m. and 5 p. m., the hours when the sea breeze has its average and maximum velocities, respectively.

TABLE 1.—*Average hourly wind velocity (miles per hour).*

	June.	July.	August.
Corpus Christi	14.2	13.3	13.3
Galveston	11.1	9.6	9.8
Port Arthur	9.2	7.7	7.1

TABLE 2.—*Average hourly wind velocity for 10 a. m. and 5 p. m.*

	June.		July.		August.	
	10 a. m.	5 p. m.	10 a. m.	5 p. m.	10 a. m.	5 p. m.
Corpus Christi	13	18	11	19	11	19
Galveston	11	12	8	12	9	12
Port Arthur	10	11	8	11	8	10

Period of observations in the above tables: For Corpus Christi and Galveston, 1911–21, inclusive; for Port Arthur, 1917–21, inclusive.

Tannehill [1] has shown that this high average wind velocity during the hottest part of the day in summer accounts for the deficient rainfall found on this coast, the continual movement of sea air landward with such great velocities preventing the formation of convectional thunderstorms upon which the summer rainfall mainly depends. It may be interesting to state that where this sea breeze begins to lessen, some 20 or 30 miles inland, thunderstorms are much more frequent than on the immediate coast. In the western part of Nueces County, near Robstown and Bishop, thunderstorms are relatively frequent during the summer months, and the formation of the thunder clouds can be plainly seen from Corpus Christi, and often thunder is heard, while clear skies are prevalent at the last-named place. Sometimes for several days in succession thunderstorms occur in the western part of the country while no rain falls on the coast. It is by no means an uncommon sight to see the air above Corpus Christi Bay perfectly clear, while convectional clouds completely cover the sky north and west of the station.

There are two causes for the increased sea breeze at Corpus Christi, viz:

1. The topography of the hinterland of Corpus Christi—a treeless plain, rising gradually and devoid of marshes.

2. The contour of the coast line at this point allowing the ocean air to reach the shore practically unimpeded.

Regarding the first cause of the abnormal sea breeze: To the north, west, and northwest of Corpus Christi lies a level prairie country, practically treeless, excepting scattered patches of mesquite. This plain increases gradually in elevation to the hilly country farther north. In the immediate vicinity of Corpus Christi for probably 30 miles inland is an ideal prairie land, about one-third under cultivation. There are no marshes in the vicinity.

When the sun's rays fall upon this plain it is heated abnormally, and there being no forests or marshes to absorb the heat or prevent its rapid radiation the natural consequence is an abnormal heating of the air immediately above. Isobaric surfaces are therefore unduly elevated, consequently the cooler ocean air flows in toward this area of barometric depression with great freedom, and of course the overflowing air from aloft assists in the circulation. On clear days the bare soil becomes so heated that this sea breeze continues far into the night, even after the time for the usual land breeze to begin. It is only on nights following days when the sea breeze has been usually weak that the typical land breeze asserts itself.

Regarding the second cause, which is of less importance: The curve in the coast line at Corpus Christi allows the southeast wind to strike the shore at such an angle that it meets with practically no resistance from a land surface before reaching the coast. It therefore comes over Corpus Christi with practically the same velocity that it has on the open ocean. To the south of this point the coast line is such that the east wind meets with

[1] I. R. Tannehill: "Wind Velocity and Rain Frequency on the South Texas Coast," MO. WEATHER REV., September, 1921.

least resistance, while on the northern coast the due south wind is the breeze that has least resistance. However, neither the east nor the south wind is the ideal sea breeze on this coast; it is the southeast wind that predominates. and this breeze finds least resistance at that part of the Texas coast between Baffins Bay and Matagorda Bay, with the greatest known velocities at Corpus Christi.

The physiological effects of this fresh breeze are pronounced. The fresh air of this locality is in marked contrast to some southern sea coasts, where stagnant coditions are frequent. Debilitating calms are relatively few on this coast, while the high-wind movement prevents that dampness and sultriness so dreaded in some subtropical regions.

In conclusion it may be said that the middle Texas coast has the swiftest and steadiest sea breeze to be found on this coast and that the land breeze is not present, except occasionally. This condition is explained by reason of the barren plains that form the hinterland of Corpus Christi, together with the favorable exposure of the place by reason of the curve in the coast line. While this increased sea breeze causes a diminution in the rainfall, it has its compensating features in the fact that a more comfortable climate is thereby created, and sultriness, sweltering heat, and damp conditions are lacking.

DOES THE FORMATION OF ABNORMALLY HEAVY ICE IN THE BERING SEA CAUSE FAMINE IN NORTHERN JAPAN? A REVIEW.

By J. B. KINCER.

Weather Bureau, Washington, D. C., October, 1922.]

By the usual custom of reasoning inductively from cause to effect, the average reader would, perhaps, have considerable difficulty in arriving at an affirmative answer to the above question. Winter scarcity or abundance of ice formation on rivers or large bodies of water concerns the American people chiefly from the viewpoint of personal or commercial convenience during the period of its prevalence and whether or not an adequate supply becomes available for storage purposes in sections where this custom obtains. To the people of Japan, however, the formation of ice in winter in the Bering Sea and neighboring waters has an entirely different and a deeper significance. Its presence in large or small amounts does not inconvenience them in winter nor do they give it a thought for summer use, but it does appear indirectly to largely control their food supply during the following year by the bearing it has on the summer temperatures on which the production of rice, in turn, depends, particularly in the northern portion of the Empire.

Rice is the dominant food crop of Japan. It normally occupies nearly one-half of the total cultivated land, with a value of about twice that of any other crop. The importance of this food to the people is very great, the per capita production being usually about 170 pounds. The high price of land and abundant labor favor an intensive form of cultivation and a product of high quality. Notwithstanding this, there is a large variation in production from year to year, especially in the north, where the summers are normally cooler than farther south. While rice is a tropical cereal thriving best in regions of high temperature and moist air, it is also grown well into the Temperate Zone, but is seldom successfully produced where the mean temperature during the four months of the active growing season is less than 75°. In Japan, however, it is cultivated northward to the 70° summer isotherm.

In this case, as in all others of like nature, where a tropical plant is grown at or near the limits of warmth requirement, the variation of temperature is of great importance, and usually determines in large measure the quantity production.

As an indication of the large variation of rice production in northern Japan, it may be mentioned that the standard deviation in yield in Hokkaido for the period from 1892–1919 was 32 per cent of the mean, expressed in koku per tan, corresponding in comparison to about 12 per cent in the production of corn in bushels per acre in our own State of Ohio. (One koku per tan is equal to about 2.1 American bushels per acre.) In recent times northern Japan had abnormally cool summers in 1902, 1905, and 1913, and in consequence these years saw great rice failures, with resulting very severe famine in most of that part of the Empire.

Owing to the fact that the prosperity of northern Japan depends so largely on the rice crop grown there and the further fact that rice production is so intimately related to the summer temperature, the question of causes for the variations in temperature has been given exhaustive study by meteorologists in that country. A paper on the subject by Dr. T. Okada, who is well and favorably known to many meteorologists in this country, was published in the *Journal of the Meteorological Society of Japan*, December, 1915, in which the relation of the intensity of the prominent centers of action, embodied in the winter Siberian HIGH and the Aleutian LOW and their counterparts, the summer Pacific anticyclone, and Asiatic depression, to the temperature in Japan was pointed out.[1] Later the same author pointed out the relation between the July temperature of our Pacific coast and that in Japan. He found in this case a negative relation between the temperature at San Francisco, Calif., and Erimo, Japan, represented by a correlation coefficient of -0.51 ± 0.10, when the variations in temperature from one year to the next were used as a basis for the computation. At the same time a rather high correlation was found between the barometric pressure in a number of western countries and the summer temperature in Japan.[2] In a succeeding note, several additional pressure-temperature relations were shown,[3] while there appeared in the *Bulletin of the Central Meteorological Observatory of Japan*, vol. 3, No. 1, 1919, a very interesting paper by Doctor Okada on the probabilities of forecasting by statistical methods the yield of rice in northern Japan from the several relations he had pointed out in his previous papers.

Up to this point Doctor Okada's studies had led to certain more or less definitely established, or suggested, relations between atmospheric conditions in different parts of the world and summer temperatures in Japan, but the meteorological explanation of these appeared rather involved, especially in view of their multiplicity. In a second paper on the possibility of forecasting the summer temperature and the approximate yield of rice in northern Japan, published in the *Memoires of the*

[1] This article was reprinted in the MO. WEATHER REV., January, 1916, 44: 17-21.
[2] MO. WEATHER REV., May, 1917, 45: 238-240.
[3] MO. WEATHER REV., November, 1917, 45: 535-538.